OPERABLE UNIT 2 CLOSURE
SOIL STUDIES

SCIENTIFIC NOTEBOOK PLAN FOR THE EVAPOTRANSPIRATION RATES IN THE ROCKY FLATS OU 2 ZONE

Rocky Flats Plant

(Operable Unit 2)

Environmental Restoration Program Division
EG&G ROCKY FLATS, INC.

Rocky Flats Plant
Golden, Colorado

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Title: Operable Unit (OU) 2 Closure Soil Studies Scientific Notebook Plan for the Evapotranspiration Rates in the Rocky Flats (RF) OU 2 Zone

1. Description:

- **Notebook Plan Title:** Evapotranspiration Rates in the Rocky Flats (RF) OU 2 Zone
- **Governing Work Plan No.:** 21100-WP-OU 02.1
- **Governing Work Plan Title:** Attachment 1.0, Surficial Soil Sampling Plan of the "Phase II RFI/RI Work Plan, Alluvial, Volume I - Text & Attachment "
- **Scientific Notebook Plan Purpose and Objective:** *(Provide sufficient detail to permit reviewers and others to understand what the work is to accomplish.)*

The information from the evapotranspiration study will be used to assess the effects of evapotranspiration on the hydrological processes at the Surficial Soil Water Monitoring Station (SSWMS) in the OU 2 Zone at Rocky Flats

The objectives of this research are to

(1) quantify microclimatic characteristics as they relate to estimating evapotranspiration rates,
(2) estimate evapotranspiration rates,
(3) develop a relationship between evapotranspiration and microclimatic characteristics,
(4) develop a computer model that will calculate evapotranspiration rates from climatic characteristics using the Bulk Transfer Method,
(5) compare actual evapotranspiration to potential transpiration rates, and
(6) develop relationships between evapotranspiration and soil moisture

2. Scientific Notebook Plan Summary: *(Describe proposed approach including procedures and methods for achieving the objectives Include analytical models, data reduction and qualification methods, and any mandatory hold-points that can be identified at this stage of the work.)*

Due to the uncertainty inherent in measuring evapotranspiration, three separate sets of instruments will be used (1) a micro-meteorological station, (2) a lysimeter, and (3) an Class-A evaporation pan These instruments will provide a check for one another as well as provide insight into actual and potential evapotranspiration

A micrometeorological station will determine atmospheric parameters necessary to calculate evapotranspiration with the Bowen Ratio Method. Measurements will include net radiation, long-wave upward radiation, wind profiles at 0 5, 2, and 5 meters, ambient air temperature profiles at 0 5, 2, and 4 meters, vapor pressure profiles at 0 5, 2, and 4 meters, soil temperature profiles at 10, 20, 30, 40, and 60 centimeters, and soil moisture profiles in 20 centimeter increments extending from 5 cm to 78 cm below the ground

Two weighing electronic, monolithic lysimeters will be set up in the field to measure the actual evapotranspiration rate The lysimeters will consist of 1 square meter by 6 meter deep, undisturbed soil monoliths excavated from the OU 2 Zone near the SSWMS The lysimeters will be placed on three electronic SSB-500 load cells that will measure the water flux Time Domain Reflectometry (TDR) probes will be inserted in the lysimeter at 10 cm intervals to measure the soil moisture profile and CSI 107B temperature probes will monitor the load cell temperature as well as measure the temperature profile at 20 cm intervals in the lysimeter The lysimeter will be in contact with a porous plate to mimic the matric potential of the surrounding soils allowing soil water to drain from both gravity and capillary action The undisturbed soil adjacent to the lysimeter will be monitored with TDR and temperature probes to compare the soil conditions in the lysimeter to the surrounding soil

A Class-A evaporation pan will measure the upper limit, or potential, evapotranspiration rate in accordance with United States Weather Bureau specifications Pan data will include rate of pan evaporation, wind speed, water temperature, and air temperature.

All electronic instruments for the lysimeter, micrometeorological station, and evaporation pan will be measured hourly with a CSI CR-10 datalogger with the data archived by RFEDS

3. Personnel:

Position	Special Qualifications/Training
Principal Investigator	
Hans M Daniels	- B S Civil Engineering - M S (in progress) - Civil Engineering specializing in evapotranspiration processes and ground water modelling
Health and Safety Technician	
John Gregg	- Eight years experience performing safety supervision and instrument monitoring on a variety of hazardous waste sites coupled with extensive field work in Levels A and B personal protective equipment and confined space entry activities - Two years college coupled with environmental, health, and safety training in the areas of Hazardous Waste Operations, Emergency Response, Radiation Safety and Worker Protection, Hazardous Chemcial Handling, Confined Space Entry, First Aid, and CPR

4. **Equipment:** *(List materials/equipment planned for the conduct of the activity, including any experimental equipment, special handling, shipping, or storage requirements)*

Equipment	Calibration Procedure (if required)
• Class-A evaporation pan	
• NovaLynx 220-200 Directional Anemometer	See instruction manual
• NovaLynx 255-100 Evaporation Sensor	See instruction manual
• NovaLynx 230-504 Relative Humidity Sensor	See instruction manual
• NovaLynx 230-201 Temperature Sensor	See instruction manual
• Interface SSB-500 Load Cells	See instruction manual
• CSI Time Domain Reflectometry Probes	See instruction manual
• CSI 107B Temperature Probes	See instruction manual
• NovaLynx Upward Long-Wave Radiometer	See instruction manual.
• CSI CR-10 Datalogger	See instruction manual
• AM416 Multiplexor	See instruction manual
• Solar Panels	See instruction manual
• Marine 675 Batteries	See instruction manual
• CSI SM716 Storage Module	See instruction manual

5. **Limitations:** *(Describe potential sources of uncertainty/error which must be controlled or measured and input data that is suspect)*

Although the SSB-500 load cell is weather resistant, it is still susceptible to temperature effects that may skew its output To compensate, the load cells will be kept out of direct sunlight, placed in an insulative environment, and will be monitored with a temperature sensor. The lysimeter will be placed inside the area from which it was excavated to reduce temperature fluctuations and wind variances Also, the lysimeter will be lifted from the load cells yearly in order to isolate the load cells and measure them for drift

The evaporation pan ideally operates when the water level is maintained at 8 inches Although water will be added or removed from the pan as needed during working days, the level will not be monitored during non-working days possibly causing the water temperature in the pan to deviate, allowing evaporation rates to continue under

non-standard conditions The volume of water in the pan can be controlled through automation to maintain a constant water level, thus ensuring standard conditions

The Time Domain Reflectometry (TDR) probes have difficulty maintaining similar output in heterogenous soil For soils that exhibit this behavior, the probes will be sheathed with a thin rubber coating A calibration procedure for the modified probe is currently being developed

The Texas Electronics TE525 Rain Gauges will be calibrated yearly according to specifications and when environmental conditions dictate

6. Quantitative/Qualitative Criteria: *(Specify quantitative criteria, i e , tolerances, operating limits, and qualitative criteria, i e , comparative samples, as appropriate, against which job performance may be evaluated.)*

The tolerances and operating limits for the electronic instruments (i.e rain gauges, temperature probes, TDR probes, anemometers, load cells, radiometers, relative humidity sensors, and evaporation sensor) are listed in the user manuals accompanying each instrument

7. Impacts on Other Activities: *(Discuss any special work environmental conditions that might be applicable, including impacts this activity might have on other activities)*

The evaporation pan, lysimeters, and the micrometeorological station will operate inside the Radiologically Controlled Area (RCA) of the Americium Zone in the OU 2 Zone south of pit four Personal Protective Equipment (PPE) will be worn as specified in the Site Health and Safety Plan

The micrometeorological instruments used for determining ET rates with the Bowen Ratio Method will be integrated with the micrometeorological instruments used in the snow melt monitoring component. Since the instruments are compatible, no adverse impact for either the snow melt or ET component is anticipated

8. Approval:

Principal Investigator — Date
Hans M Daniels

Project Manager — 7-7-94 Date
Michael Z Litaor

Technical Reviewer — 7/8/94 Date
Tissa Illangasakare

EQS QAPM — 7/6/94 Date
Steve Luker

APPENDIX I

The Bowen Ratio Method is considered the most appropriate micrometeorological method for measuring evapotranspiration on a continuous basis (Malek, 1993, Gay and Greenberg, 1985, Revfeim and Jordan, 1976) The following derivation from Malek, 1993 describes the Bowen Ration Method

The energy balance equation is

$$R_n + G_{surf} = H + LE \qquad (1)$$

where R_n, G_{surf}, H, and LE are net, soil (negative when the soil warms up), sensible, and latent heat fluxes, respectively

The Bowen Ratio, β, is

$$\beta = H/LE = C_p d\theta / L dq \qquad (2)$$

where C_p is the specific heat of air at constant pressure, $1005(1 + 0\ 90q) Jkg^{-1}K^{-1}$, and $d\theta$ and dq are the vertical gradients of potential temperature (K) and of specific humidity (kg of water per kg of moist air), respectively

From equations (1) and (2), LE can be computed as

$$LE\ (R_n + G_{surf})/(1 + \beta) \qquad (3)$$

Evapotranspiration can be computed from the latent heat (LE) by using the following relationship.

$$LE = \rho_w L\ ET \qquad (4)$$

where ρ_w is the density of water (1000 kg m^{-3}), L is 2,500,800 - 2366 8 T (°C), and ET is evapotranspiration